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Abstracts of recently accepted papers

Molecular cloud structure and star formation near HH 216 in M 16

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We present millimetre, optical, and near-infrared observations of M 16 in the vicinity of the Herbig-Haro object HH 216. The line profiles of the CO($J = 2 - 1$) spectra are broad and consist of both emission originating from four warm molecular cores and a large cloud or cloud system across the whole field. The CS($J = 2 - 1$) and the $C^{18}O$($J = 2 - 1$) lines are relatively broad compared with those observed in low-mass star formation regions, but not unusually broad for higher-mass star-forming regions. The virial masses found are much larger than the mass estimates based on the assumption of LTE. The optical images suggest that HH 216 is the terminating bow shock of a large Herbig-Haro flow which includes a jet. A possible location for the driving source is suggested, from the presence of a very reddened point source associated with what may be a small reflection nebula at the tip of a dense molecular 'trunk'. Another reflection nebula associated with the same core is also detected. This demonstrates that star formation is taking place in the trunk.

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An empirical criterion to classify T Tauri stars and substellar analogs using low-resolution optical spectroscopy

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We have compiled and studied photometric and spectroscopic data published in the literature of several star forming regions and young open clusters (Orion, Taurus, IC348, Sco-Cen Complex, Chamaeleon I, TW Hya association, σ Orionis cluster, IC2391, α Per cluster and the Pleiades). Our goal was to seek the definition of a simple empirical criterion to classify stars or brown dwarfs which are accreting matter from a disk on the sole basis of low-resolution optical spectroscopic data. We show that using Hα equivalent widths and spectral types we can statistically classify very young stars and brown dwarfs as classical T Tauri stars and substellar analogs. As a boundary between accreting and non accreting objects, we use the saturation limit of chromospheric activity at Log $\{L(H\alpha)/L(bol)\}=-3.3$ (determined in the open clusters). We discuss the uncertainties in the classification scheme due to the occurrence of

flares. We have used this spectroscopic empirical criterion to classify objects found in the literature, and we compute the fraction of accreting objects in several star forming regions. The fraction of accreting objects appears to decrease from about 50% to about 5% from 1 Myr to 10 Myr for both stars and brown dwarfs.

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The 3-Dimensional Structure of HH 32 from GMOS IFU Spectroscopy

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We present new high resolution spectroscopic observations of the Herbig-Haro object HH 32 from System Verification observations made with the GMOS IFU at Gemini North Observatory. The 3D spectral data covers a $8''.7 \times 5''.85$ spatial field and 4820 - 7040 Å spectral region centered on the HH 32 A knot complex. We show the position-dependent line profiles and radial velocity channel maps of the Hα line, as well as line ratio velocity channel maps of [O III] 5007/Hα, [O I] 6300/Hα, [N II] 6583/Hα, [S II] (6716+6730)/Hα and [S II] 6716/6730. We find that the line emission and the line ratios vary significantly on spatial scales of $\sim 1''$ and over velocities of $\sim$50 km/s. A "3/2-D" bow shock model is qualitatively successful at reproducing the general features of the radial velocity channel maps, but it does not show the same complexity as the data and it fails to reproduce the line ratios in our high spatial resolution maps. The observations of HH 32 A show two or three superimposed bow shocks with separations of $\sim 3''$, which we interpret as evidence of a line of sight superposition of two or three working surfaces located along the redshifted body of the HH 32 outflow.

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Millimeter observations of the IRAS 18162-2048 outflow: evidence for cloud disruption around an intermediate-mass protostar

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In order to study the morphology and dynamics of the molecular outflow associated with IRAS 18162-2048, a wide area of $\sim$95 arcmin^2 around the source has been mapped by means of CO and ^{13}CO (1-0) lines, and complemented by a map of a smaller region surrounding the high-mass object using the C^{18}O(1-0) and CH_3OH (2_k-1_k) and (3_k-2_k) transitions. The lines profile reveals the presence of several velocity components among which two major line components at 11.9 and 12.8 km s^{-1} have been detected in all the tracers.

Simple morphological and energetic considerations led us to interpret the observations in a relatively straightforward scenario in which the powerful jet ejected by IRAS 18162-2048 sets a big portion of the surrounding molecular cloud into motion. The energy and momentum deposited by the flow breaks the cloud apart, shifting to a blue velocity the northern region and to a red velocity the southern region, and giving rise to a giant outflow. We calculated the physical parameters of the outflow, which makes the IRAS 18162-2048 outflow, as one of the most massive (M=570 M$_\odot$) and energetic (K>10^{46} ergs) knowns. Despite the intrinsic difficulties in giving a precise value of the age and the inclination angle of the flow, we used different methods to derive a reliable estimate. Our data show evidence in favor

of a small inclination angle (<50°) and of a maximum outflow age of $\sim 10^6$ yr.

$C^{18}O$ and CH_3OH trace the dense core surrounding IRAS 18162-2048 and show an elongated emission in the direction perpendicular to the outflow axis. Besides the peak emission associated with the IRAS source, we found another peak at the position RA(B1950)=$18^h16^m20.2^s$ DEC(B1950)=-20°49′18″ which coincides with a red near infrared source. We provided evidence that this second peak may be surrounded by a flattened rotating structure, suggesting that the newly discovered IR source can be another site of recent star formation in this region.

Our analysis suggest that the powerful wind/outflow from the luminous stars within the young cluster embedded in the GGD27 nebula are tearing apart the parental molecular cloud. The IRAS 18162-2048 appears to be in the act of clearing the surrounding material on the verge of becoming an optically revealed young stellar cluster, similar to those associated with Herbig Be stars.

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Really Cool Stars and the Star Formation History at the Galactic Center

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We present $\lambda/\Delta\lambda$ = 550 to 1200 near infrared H and K spectra for a magnitude limited sample of 79 asymptotic giant branch and cool supergiant stars in the central ≈ 5 pc (diameter) of the Galaxy. We use a set of similar spectra obtained for solar neighborhood stars with known $T_{\rm eff}$ and $M_{\rm bol}$ that is in the same range as the Galactic center (GC) sample to derive $T_{\rm eff}$ and $M_{\rm bol}$ for the GC sample. We then construct the Hertzsprung–Russell (HRD) diagram for the GC sample. Using an automated maximum likelihood routine, we derive a coarse star formation history of the GC. We find (1) roughly 75% of the stars formed in the central few pc are older than 5 Gyr; (2) the star formation rate (SFR) is variable over time, with a roughly 4 times higher star formation rate in the last 100 Myr compared to the average SFR; (3) our model can only match dynamical limits on the total mass of stars formed by limiting the IMF to masses above 0.7 $M_\odot$. This could be a signature of mass segregation or of the bias toward massive star formation from the unique star formation conditions in the GC; (4) blue supergiants account for 12 % of the total sample observed, and the ratio of red to blue supergiants is roughly 1.5; (5) models with isochrones with [Fe/H] = 0.0 over all ages fit the stars in our HRD better than models with lower [Fe/H] in the oldest age bins, consistent with the finding of Ramirez et al. (2000) that stars with ages between 10 Myr and 1 Gyr have solar [Fe/H].

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The Spatial Structure of the β Pictoris Gas Disk

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We have used VLT/UVES to spatially resolve the gas disk of β Pictoris. 88 extended emission lines are observed, with the brightest coming from Fe I, Na I and Ca II. The extent of the gas disk is much larger than previously anticipated; we trace Na I radially from 13 AU out to 323 AU and Ca II to heights of 77 AU above the disk plane, both to the limits of our observations. The degree of flaring is significantly larger for the gas disk than the dust disk. A strong NE/SW brightness asymmetry is observed, with the SW emission being abruptly truncated at 150–200 AU. The inner gas disk is tilted about 5° with respect to the outer disk, similar to the appearance of the disk in light scattered from dust. We show that most, perhaps all, of the Na I column density seen in the 'stable' component of absorption, comes from the extended disk. Finally, we discuss the effects of radiation pressure in the extended gas disk and show that the assumption of hydrogen, in whatever form, as a braking agent is inconsistent with observations.

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Local Interstellar Medium Kinematics towards the Southern Coalsack and Chamaeleon-Musca dark clouds

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The results of a spectroscopic programme aiming to investigate the kinematics of the local interstellar medium components towards the Southern Coalsack and Chamaeleon-Musca dark clouds are presented. The analysis is based upon high-resolution ($R \approx 60\,000$) spectra of the insterstellar NaI D absorption lines towards 63 B-type stars ($d \leq 500$ pc) selected to cover these clouds and the connecting area defined by the Galactic coordinates: $308° \geq l \geq 294°$ and $-22° \leq b \leq 5°$. The radial velocities, column densities, velocity dispersions, colour excess and photometric distances to the stars are used to understand the kinematics and distribution of the interstellar cloud components. The analysis indicates that the interstellar gas is distributed in two extended sheet-like structures permeating the whole area, one at $d \leq 60$ pc and another around 120-150 pc from the Sun. The nearby feature is approaching to the local standard of rest with average radial velocity of -7 km s^{-1}, has low average column density $\log N_{\rm Na\,I} \approx 11.2$ cm^{-2} and velocity dispersion b ≈ 5 km s^{-1}. The more distant feature has column densities between $12.3 \leq \log N_{\rm Na\,I} \leq 13.2$, average velocity dispersion b ≈ 2.5 km s^{-1} and seems associated to the dust sheet observed towards the Coalsack, Musca and Chamaeleon direction. Its velocity is centered around 0 km s^{-1}, but there is a trend for increasing from -3 km s^{-1} near $b = 1°$ to 3 km s^{-1} near $b = -18°$. The nearby low column density feature indicates a general outflow from the Sco-Cen association, in aggreement with several independent lines of data in the general searched direction. The dust and gas feature around 120 – 150 pc seem to be part of an extended large scale feature of similar kinematic properties, supposedly identified with the interaction zone of the Local and Loop I bubbles. Assuming that the interface and the ring-like volume of dense neutral matter that would have been formed during the collision of the two bubbles have similar properties, our results rather suggest that the interaction zone between the bubbles is twisted and folded.

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SCUBA Polarization Measurements of the Magnetic Field Strengths in the L183, L1544, and L43 Prestellar Cores

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We have mapped linearly polarized dust emission from L183 with the JCMT SCUBA polarimeter and have analyzed these and our previously published data for the prestellar cores L183, L1544, and L43 in order to estimate magnetic field strengths in the plane of the sky, B_{pos}. The analysis used the Chandrasekhar-Fermi technique, which relates the dispersion in polarization position angles to B_{pos}. We have used these estimates of the field strengths (neglecting the unmeasured line-of-sight component) to find the mass-to-magnetic flux ratios λ (in units of the critical ratio for magnetic support). Results are $B_{pos} \approx 80$ μG and $\lambda \approx 2.6$ for L183, $B_{pos} \approx 140$ μG and $\lambda \approx 2.3$ for L1544, and $B_{pos} \approx 160$ μG and $\lambda \approx 1.9$ for L43. Hence, without correction for geometrical biases, for all three cores the mass-to-flux ratios are supercritical by a factor of ~ 2, and magnetic support cannot prevent collapse. However, a statistical mean correction for geometrical bias may be up to a factor of three; this correction would reduce the individual λ's to $\lambda_{cor} \approx 0.9$, 0.8, and 0.6, respectively; these values are approximately critical or slightly subcritical. These data are consistent with models of star formation driven by ambipolar diffusion in a weakly turbulent medium, but cannot rule out models of star formation driven by turbulence.

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A Search for Mid-Infrared Emission from Hot Molecular Core Candidates

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We present here mid-infrared images of seven sites of water maser emission thought to be associated with the hot molecular core (HMC) phase of massive star formation. We have detected mid-infrared emission from the locations of two of these HMC candidates, G11.94-0.62 and G45.07-0.13. From our observations we derived lower limit estimates of the luminosities for the exciting sources in these two HMCs. We find that the estimates are consistent with the hypothesis that the HMCs are internally heated by massive B and O type stars. We observed two sites with HMCs previously claimed to be detected in the mid-infrared, G19.61-0.23 and G34.26+0.15, however we did not detect mid-infrared emission from either HMC location. We place new upper limits on the mid-infrared flux densities for these HMCs that are much lower than their previously reported flux densities. We were also able to obtain extremely accurate astrometry for our mid-infrared observations of G9.62+0.19 and conclude that the mid-infrared emission previously thought to be coming from the HMC in this field is in fact coming from a different source altogether.

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Laboratory and radio-astronomical spectroscopy of the hyperfine structure of N_2D^+

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We present the first laboratory measurements of the hyperfine structure of the $J = 1 \rightarrow 0$ rotational transition of N_2D^+, a good tracer of the dense regions of molecular cloud cores, and the spectra of unresolved high J transitions recorded in the $308 - 463$ GHz region. Together with a high sensitivity radio–astronomical spectrum of the N_2D^+ $J = 1 \rightarrow 0$ rotational transition in a quiescent cloud core, we determined with high precision the frequencies of the seven hyperfine components and the molecular spectroscopic constants, allowing us to make predictions on the N_2D^+ frequencies of higher J transitions occurring in the submillimeter–wave region.

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Giant Molecular Clouds in M33 I – BIMA All-Disk Survey

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We present the first interferometric CO (J=1→0) map of the entire Hα disk of M33. The 13″ diameter synthesized beam corresponds to a linear resolution of 50 pc, sufficient to distinguish individual giant molecular clouds (GMCs). From these data we generated a catalog of 148 GMCs with an expectation that no more than 15 of the sources are spurious. The catalog is complete down to GMC masses of 1.5×10^5 $M_\odot$ and contains a total mass of 2.3×10^7 $M_\odot$. Single dish observations of CO in selected fields imply that our survey detects $\sim$ 50% of the CO flux, hence that the total molecular mass of M33 is 4.5×10^7 $M_\odot$, approximately 2% of the HI mass. The GMCs in our catalog are

confined largely to the central region ($R < 4$ kpc). They show a remarkable spatial and kinematic correlation with overdense HI filaments; the geometry suggests that the formation of GMCs follows that of the filaments. The GMCs exhibit a mass spectrum $dN/dM \propto M^{-2.6\pm0.3}$, considerably steeper than that found in the Milky Way and in the LMC. Combined with the total mass, this steep function implies that the GMCs in M33 form with a characteristic mass of $\sim 7 \times 10^4 M_\odot$. More than 2/3 of the GMCs have associated HII regions, implying that the GMCs have a short quiescent period. Our results suggest the rapid assembly of molecular clouds from atomic gas, with prompt onset of massive star formation.

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Magnetically driven outflows from Jovian circum-planetary accretion disks

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We discuss the possibility to launch an outflow from the close vicinity of a protoplanetary core considering a model scenario where the protoplanet surrounded by a circum-*planetary* accretion disk is located in a circum-*stellar* disk. For the circum-planetary disk accretion rate we assume $\dot{M}_{\rm cp} \simeq 6 \times 10^{-5} M_{\rm jup} {\rm yr}^{-1}$ implying peak disk temperatures of about 2000 K. The estimated disk ionization degree and Reynolds number allow for a sufficient coupling between the disk matter and the magnetic field. We find that the surface magnetic field strength of the protoplanet is probably not more than 10 G, indicating that the *global* planetary magnetosphere is dominated by the circum-planetary disk magnetic field of $\lesssim$50 G. The existence of a gap between circum-planetary disk and planet seems to be unlikely. The estimated field strength and mass flow rates allow for asymptotic outflow velocities of $\gtrsim$60 km s^{-1}. The overall outflow geometry will be governed by the orbital radius, resembling a hollow tube or cone perpendicular the disk. The length of the outflow built up during one orbital period is about 100 AU, depending on the outflow velocity. Outflows from circum-planetary disks may be visible in shock excited emission lines along a tube of diameter of the orbital radius and thickness of about 100 protoplanetary radii. We derive particle densities of 3000 cm^{-3} in this layer. Energetically, protoplanetary outflows cannot survive the interaction with a *protostellar* outflow. Due to the efficient angular momentum removal by the outflow, we expect the protoplanetary outflow to influence the early planet angular momentum evolution. If this is true, planets which have produced an outflow in earlier times will rotate slower at later times. The mass evolution of the planet is, however, hardly affected as the outflow mass loss rate will be small compared to the mass accumulated by the protoplanetary core.

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A Turbulent Interstellar Medium Origin of the Binary Period Distribution

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In this paper, we present a semi-empirical model of isolated binary star formation. This model includes the effects of turbulence in the initial state of the gas, and has binary orbital parameters consistent with observation. This model therefore provides a framework with which to examine the relative importance of turbulence in the context of isolated binary star formation, and to make quantitative predictions to compare against observation. The primary results of this model are as follows. (i) A quantitative prediction of the initial width of the binary period distribution ($\sigma_{\log P_d} = 1.6 - 2.1$ for a star formation efficiency in the range $\epsilon_* = 0.1 - 0.9$). (ii) A robust anticorrelation of binary period and mass ratio. (iii) A robust, positive correlation of binary period and eccentricity. (iv) A robust prediction that the binary separation of low-mass systems should be more closely separated than those of solar-mass or larger. These predictions are in good agreement with observations of PMS binary systems with periods $P > 10^3$ d, which account for the majority of all binaries.

We conclude with a brief discussion of the implications of our results for observational and theoretical studies of multiple star formation.

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Structuring and support by Alfvén waves around prestellar cores

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Observations of molecular clouds show the existence of starless, dense cores, threaded by magnetic fields. Observed line widths indicate these dense condensates to be embedded in a supersonically turbulent environment. Under these conditions, the generation of magnetic waves is inevitable. In this paper, we study the structuring and support of a 1D plane-parallel, self-gravitating slab, as a monochromatic, circularly polarized Alfvén waves is injected at its central plane. Dimensional analysis shows that the solution must depend on three dimensionless parameters. To study the nonlinear, turbulent evolution of such a slab, we use 1D high resolution numerical simulations. For a parameter range inspired by molecular cloud observations, we find the following. 1) A single source of energy injection is sufficient to force persistent supersonic turbulence over several hydrostatic scale heights. 2) The time averaged spatial extension of the slab is comparable to the extension of the stationary, analytical WKB solution. Deviations, as well as the density substructure of the slab, depend on the wave-length of the injected wave. 3) Energy losses are dominated by loss of Poynting-flux and increase with increasing plasma beta. 4) Good spatial resolution is mandatory, making similar simulations in 3D currently prohibitively expensive.

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http://www.astro.phys.ethz.ch/papers/folini/

First evidence for dusty disks around Herbig Be stars

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We have carried out a high-sensitivity search for circumstellar disks around Herbig Be stars in the continuum at 1.4mm and 2.7mm using the IRAM interferometer at the Plateau de Bure (PdBI) . In this letter, we report data on three well studied B0 stars, MWC 1080, MWC 137 and R Mon. The two latter have also been observed in the continuum at 0.7 cm and 1.3 cm using the NRAO Very Large Array (VLA) . We report the detection of circumstellar disks around MWC 1080 and R Mon with masses of $M_d \sim 0.003$ and 0.01 $M_\odot$, respectively, while for MWC 137 we estimate a disk mass upper limit of 0.007 $M_\odot$. Our results show that the ratio M_d/M_* is at least an order of magnitude lower in Herbig Be stars than in Herbig Ae and T Tauri stars.

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Interferometric Observations of FeO towards Sagittarius B2

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We have used the Nobeyama Millimeter Array (NMA) to carry out aperture synthesis observations of the J=5–4 ground state rotational transition of FeO molecule at 153.135273 GHz towards the galactic center HII region Sagittarius B2 Main (Sgr B2 M). We confirm the detection of this line in absorption with the IRAM 30-m telescope by Walmsley et al. (2002, WBPS). Due to the higher angular resolution ($6.''5 \times 3.''0$) of our NMA observations, we were able to show that the absorption has a broader line width and a deeper apparent optical depth toward the central $9.''2 \times 8.''0$ area around the ultra-compact (UC) HII regions. This suggests a higher column density of FeO towards the UCHII regions associated with Sgr B2 M than along adjacent lines of sight sampled with the IRAM 30-m telescope. Our results will be a crucial step toward understanding not only the chemistry of iron-bearing species in the interstellar medium, but also the degree of depletion of heavy elements.

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http://www.astro.caltech.edu/~rsf/publication.html

Testing Protoplanetary Disk Alignment in Young Binaries

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We present K-band (2.2 μm) imaging polarimetry that resolves 19 T Tauri binary and multiple systems in the Taurus-Auriga and Scorpius-Ophiuchus star forming regions. We observed systems with projected separations $1.''5$–$7.''2$ ($\sim$200–1000 AU) in order to determine the relative orientation of the circumstellar disks in each binary system. Scattered light from these disks is polarized, allowing us to deduce the position angle of the disk on the sky from the position angle of polarization even though our observations do not resolve the disks themselves. We detected measurable polarization (typically 0.5% to 2%, with typical uncertainty 0.1%) from both stars in 14 of the systems observed. In 8 of the 9 binary systems, the two stars' polarization position angles are within 30° of each other, inconsistent with random orientations. In contrast, the five triple and quadruple systems appear to have random disk orientations when comparing the polarization position angles of the widest pair in the system; the close pairs are unresolved in all but one system. Our observations suggest that disks in wide (200–1000 AU) binaries are aligned with each other within $< 20°$ but not perfectly co-planar. However, we cannot conclusively rule out random relative disk orientations if the observed polarizations are significantly contaminated by interstellar polarization. Even in the presence of interstellar polarization our observations securely exclude co-planar disks. These results provides constraints on possible binary formation mechanisms if the observed orientations are primordial. On the other hand, models of disk-binary interactions indicate that the disks may have had time to decrease their relative inclinations since formation. If the common orientation of the disks in these binaries is a tracer of the binary orbital plane, then our results also have significance for the stability of planetary orbits, suggesting that planetary systems in wide binaries should be stable over 10^9-year timescales.

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On the Formation of Brown Dwarfs

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The observational properties of brown dwarfs pose challenges to the theory of star formation. Because their mass

is much smaller than the typical Jeans mass of interstellar clouds, brown dwarfs are most likely formed through secondary fragmentation processes, rather than through the direct collapse of a molecular cloud core. In order to prevent substantial post-formation mass accretion, young brown dwarfs must leave the high density formation regions in which they form. We propose here that brown dwarfs are formed in the circumbinary disks. Through post-formation dynamical interaction with their host binary stars, young brown dwarfs are either scattered to large distance or removed, with modest speed, from their cradles.

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Astrochemistry of Sub-Millimeter Sources in Orion: Studying the Variations of Molecular Tracers with Changing Physical Conditions

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Cornerstone molecules (CO, H_2CO, CH_3OH, HCN, HNC, CN, CS, SO) were observed toward seven sub-millimeter bright sources in the Orion molecular cloud in order to quantify the range of conditions for which individual molecular line tracers provide physical and chemical information. Five of the sources observed were protostellar, ranging in energetics from $1 - 500\,L_\odot$, while the other two sources were located at a shock front and within a photodissociation region (PDR).

Statistical equilibrium calculations were used to deduce from the measured line strengths the physical conditions within each source and the abundance of each molecule. In all cases except the shock and the PDR, the abundance of CO with respect to H_2 appears significantly below (factor of ten) the general molecular cloud value of 10^{-4}. Formaldehyde measurements were used to estimate a mean temperature and density for the gas in each source. Evidence was found for trends between the derived abundance of CO, H_2CO, CH_3OH, and CS and the energetics of the source, with hotter sources having higher abundances. Determining whether this is due to a linear progression of abundance with temperature or sharp jumps at particular temperatures will require more detailed modeling. The observed methanol transitions require high temperatures ($T > 50$ K), and thus energetic sources, within all but one of the observed protostellar sources. The same conclusion is obtained from observations of the CS 7-6 transition. Analysis of the HCN and HNC 4-3 transitions provides further support for high densities $n > 10^7$ cm^{-3} in all the protostellar sources.

The shape of the CO 3–2 line profile provides evidence for internal energetic events (outflows) in all but one of the protostellar sources, and shows an extreme kinematic signature in the shock region. In general, the CO line and its isotopes do not significantly contaminate the $850\,\mu m$ broadband flux (less than 10%); however, in the shock region the CO lines alone account for more than two thirds of the measured sub-millimeter flux. In the energetic sources, the combined flux from all other measured molecular lines provides up to an additional few percent of line contamination.

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The structure of the NGC 1333-IRAS2 protostellar system on 500 AU scales: an infalling envelope, a circumstellar disk, multiple outflows, and chemistry

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This paper investigates small-scale (500 AU) structures of dense gas and dust around the low-mass protostellar binary NGC 1333-IRAS2 using millimeter-wavelength aperture-synthesis observations from the Owens Valley and Berkeley-Illinois-Maryland-Association interferometers. The detected $\lambda = 3$ mm continuum emission from cold dust is consistent with models of the envelope around IRAS2A, based on previously reported submillimeter-continuum images, down to the $3''$, or 500 AU, resolution of the interferometer data. Our data constrain the contribution of an unresolved point source to 22 mJy. The importance of different parameters, such as the size of an inner cavity and impact of the interstellar radiation field, is tested. Within the accuracy of the parameters describing the envelope model, the point source flux has an uncertainty by up to 25%. We interpret this point source as a cold disk of mass $\gtrsim 0.3\ M_\odot$. The same envelope model also reproduces aperture-synthesis line observations of the optically thin isotopic species $C^{34}S$ and $H^{13}CO^+$. The more optically thick main isotope lines show a variety of components in the protostellar environment: N_2H^+ is closely correlated with dust concentrations as seen at submillimeter wavelengths and is particularly strong toward the starless core IRAS2C. We hypothesize that N_2H^+ is destroyed through reactions with CO that is released from icy grains near the protostellar sources IRAS2A and B. CS, HCO^+, and HCN have complex line shapes apparently affected by both outflow and infall. In addition to the east-west jet seen in SiO and CO originating from IRAS2A, a north-south velocity gradient near this source indicates a second, perpendicular outflow. This suggests the presence of a binary companion within $0\farcs3$ (65 AU) from IRAS2A as driving source of this outflow. Alternative explanations of the velocity gradient, such as rotation in a circumstellar envelope or a single, wide-angle (90°) outflow are less likely.

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Collisional Cascades in Planetesimal Disks II. Embedded Planets

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We use a multiannulus planetesimal accretion code to investigate the growth of icy planets in the outer regions of a planetesimal disk. In a quiescent minimum mass solar nebula, icy planets grow to sizes of 1000–3000 km on a timescale $t_P \approx 15 - 20$ Myr $(a/30\ \mathrm{AU})^3$, where a is the distance from the central star. Planets form faster in more massive nebulae. Newly-formed planets stir up leftover planetesimals along their orbits and produce a collisional cascade where icy planetesimals are slowly ground to dust.

The dusty debris of planet formation has physical characteristics similar to those observed in β Pic, HR 4796A, and other debris disks. The computed dust masses are $M_d(r \le 1\ \mathrm{mm}) \sim 10^{26}$ g (M_0/M_{MMSN}) and $M_d(1\ \mathrm{mm} \le r \le 1\ \mathrm{m}) \sim 10^{27}$ g (M_0/M_{MMSN}), where r is the radius of a particle, M_0 is the initial mass in solids, and M_{MMSN} is the mass in solids of a minimum mass solar nebula at 30–150 AU. The luminosity of the dusty disk relative to the stellar luminosity is $L_D/L_0 \sim L_{max}(t/t_0)^{-m}$, where $L_{max} \sim 10^{-3}(M_0/M_{MMSN})$, $t_0 \approx 10$ Myr to 1 Gyr, and $m \approx$ 1–2. Our calculations produce bright rings and dark gaps with sizes $\Delta a/a \approx 0.1$. Bright rings occur where 1000 km and larger planets have recently formed. Dark gaps are regions where planets have cleared out dust or shadows where planets have yet to form.

Planets can also grow in a planetesimal disk perturbed by the close passage of a star. Stellar flybys initiate collisional cascades, which produce copious amounts of dust. The dust luminosity following a modest perturbation is 3–4 times larger than the maximum dust luminosity of a quiescent planet-forming disk. In 10 Myr or less, large perturbations remove almost all of the planetesimals from a disk. After a modest flyby, collisional damping reduces planetesimal velocities and allows planets to grow from the remaining planetesimals. Planet formation timescales are then 2–4 times longer than timescales for undisturbed disks; dust luminosities are 2–4 times smaller.

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`animations and figures: http://cfa-www.harvard.edu/~kenyon/pf/emb-planet-movies.html`

Dynamical Processes in the Neighborhood of the Herbig Ae Star MWC 480 Based on Spectral Monitoring Data

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Spectral observations of the Herbig Ae star MWC 480 are reported. Observations were made on the 2.6 m telescope at the Crimean Astrophysical Observatory and the 6 m telescope at the Special Astrophysical Observatory in the neighborhoods of the sodium resonance doublet, the He I λ 5876 A line, the oxygen O I λ 7774 A line, the Hα line, and some others. The Hα line has a P Cyg-type profile which is typical of anisotropic decelerated material outflows. The parameters of the line profile vary on a time scale on the order of days or longer. The blue wing of the line profile, in which noticeable changes are detectable over times of a few hours, is subject to the greatest variation. An unusual line shape is observed in the sodium lines. Their profiles resemble type P Cyg profiles with discrete absorption components can be seen in the blue wing. The number, shape, and radial velocities of the components change with time. The maximum radial velocity is -330 km/s and the minimum, about -50 km/s. The high velocity components are subject to the greatest variability. An analysis of the spectral variability yields the following conclusions: (1) the inner layers of the accretion disk of MWC 480 reach right to the star. The maximum rotation velocity of the circumstellar gas derived from the oxygen OI 7774 A line shape is close to 400-500 km/s, which corresponds roughly to the radius of the last Keplerian orbit. (2) A highly nonuniform, high velocity component of the disk wind, which contains dense fragments (microjets), develops in this region. They appear to form as a result of the unstable structure of the magnetic field in the layers of the accretion disk closest to the star. (3) The maximum velocities of the microjets are only slightly higher than the escape velocity at the star's surface. Thus, the bulk of the momentum which they acquire is expended in overcoming the star's gravity and this causes a deceleration in the radial motion of the gas. This kind of structure for the radiating region is consistent with magneto-centrifugal models of the disk wind in which the intrinsic magnetic field of the accretion disk plays a dominant role in the acceleration of the gas.

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First NACO observations of the Brown Dwarf LHS 2397aB

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Observations of the standard late type M8 star LHS 2397aA were obtained at the ESO-VLT 8m telescope "Yepun" using the NAOS/CONICA Adaptive Optics facility. The observations were taken during the NACO commissioning, and the infrared standard star LHS 2397aA was observed in the H, and Ks broad band filters. In both bands the brown dwarf companion LHS 2397aB was detected. Using a program recently developed (Bouy et al., 2003) for the detection of stellar binaries we calculated the principal astrometric parameters (angular binary separation and position angle P.A.) and the photometry of LHS 2397aA and LHS 2397aB. Our study largely confirms previous results obtained with the AO-Hokupa'a facility at Gemini-North (Freed et al., 2003); however a few discrepancies are observed.

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Mid-IR spectroscopy of T Tauri stars in Chamaeleon I: evidence for processed dust at the earliest stages

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We present mid-IR spectroscopy of three T Tauri stars in the young Chamealeon I dark cloud obtained with TIMMI2 on the ESO 3.6m telescope. In these three stars, the silicate emission band at 9.7 μm is prominent. We model it with a mixture of amorphous olivine grains of different size, crystalline silicates and silica. The fractional mass of these various components change widely from star to star. While the spectrum of CR Cha is dominated by small amorphous silicates, in VW Cha (and in a lesser degree in Glass I), there is clear evidence of a large amount of processed dust in the form of crystalline silicates and large amorphous grains. This is the first time that processed dust has been detected in very young T Tauri stars ($\sim$ 1 Myr).

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Ten-micron Observations of Nearby Young Stars

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We present new 10μm photometry of 21 nearby young stars obtained at the Palomar 5-meter and at the Keck I 10-meter telescopes as part of a program to search for dust in the habitable zone of young stars. Thirteen of the stars are in the F–K spectral type range ("solar analogs"), 4 have B or A spectral types, and 4 have spectral type M. We confirm existing *IRAS* 12μm and ground-based 10μm photometry for 10 of the stars, and present new insight into this spectral regime for the rest. Excess emission at 10μm is not found in any of the young solar analogs, except for a possible 2.4-sigma detection in the G5V star HD 88638. The G2V star HD 107146, which does not display a 10μm excess, is identified as a new Vega-like candidate, based on our 10μm photospheric detection, combined with previously unidentified 60μm and 100μm *IRAS* excesses. Among the early-type stars, a 10μm excess is detected only in HD 109573A (HR 4796A), confirming prior observations; among the M dwarfs, excesses are confirmed in AA Tau, CD –40 8434, and Hen 3–600A. A previously suggested N band excess in the M3 dwarf CD –33 7795 is shown to be consistent with photospheric emission.

We calculate infrared to stellar bolometric luminosity ratios for all stars exhibiting mid-infrared excesses, and infer the total mass of orbiting dust in the cases of optically thin disks. For a derived median photometric precision of $\pm$0.11 mag, we place an upper limit of $M_{\rm dust} \approx 2 \times 10^{-5} M_\oplus$ on the dust mass (assuming a dust temperature of 300 K) around solar analogs not seen in excess at 10μm. Our calculations for the nearby K1V star HD 17925 show that it may have the least massive debris disk known outside our solar system ($M_{\rm dust} \geq 7 \times 10^{-6} M_\oplus$).

Our limited data confirm the expected tendency of decreasing fractional dust excess $f_d = L_{\rm IR}/L_*$ with increasing stellar age. However, we argue that estimates of f_d suffer from a degeneracy between the temperature and the amount of circumstellar dust $M_{\rm dust}$, and propose a relation of $M_{\rm dust}$ as a function of age, instead.

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Various manifestations of the outflow connected to the cometary nebula GM 3-12 (RNO 124)

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We present the results of imaging and scanning Fabry-Pérot interferometry of the cometary nebula GM 3-12 (RNO 124) and Herbig-Haro object HH 376A. The nebula is cone-shaped with the star IRAS 20359+6745 at the apex, straight walls and two probable helical arms. HH 376A is the bow shock structure in the collimated high velocity flow, directed by the axis of the cone nebula, with shock velocity about 70-80 km s^{-1}. The spatial and kinematical separation between bow shock and Mach disk in HH 376A was not detected, which makes this object similar to HH 111. The Hα profiles in the vicinity of the source are double peaked. The high velocity component can be attributed to the collimated flow.

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An optical and near-infrared exploration of the star formation region in Cygnus surrounding RNO127

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We investigate a relatively unstudied star formation region in Cygnus centered on RNO 127, finding numerous Herbig-Haro flows, many identified in optical [SII], Hα, and near-infrared H_2 tracers of shock waves. Several protostars and young stars are thus located, including one conspicuously brightened object, which illuminates a variable reflection nebula. In total, the coordinates of 17 optical HH knots and jets, 4 associated cometary nebulae and 3 NIR objects are given. Individual structures are discussed including a central complex which has the characteristics of superposed HH flows. This star-forming cloud is not isolated but is part of a much larger region of distributed star formation, including HH380 and HH381.

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On the evolution of giant protoplanets forming in circumbinary discs

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We present the results of hydrodynamic simulations of Jovian mass protoplanets that form in circumbinary discs. The simulations follow the orbital evolution of the binary plus protoplanet system acting under their mutual gravitational forces, and forces exerted by the viscous circumbinary disc. The evolution involves the clearing of the inner circumbinary disc initially, so that the binary plus protoplanet system orbits within a low density cavity. Continued interaction between disc and protoplanet causes inward migration of the planet towards the inner binary. Subsequent evolution can take three distinct paths: (*i*) The protoplanet enters the 4:1 mean motion resonance with the binary, but is gravitationally scattered through a close encounter with the secondary star; (*ii*) The protoplanet enters the 4:1 mean motion resonance, the resonance breaks, and the planet remains in a stable orbit just outside the resonance; (*iii*) When the binary has initial eccentricity $e_{bin} \geq 0.2$, the disc becomes eccentric, leading to a stalling of the planet migration, and the formation of a stable circumbinary planet.

These results have implications for a number of issues in the study of extrasolar planets. The ejection of protoplanets in close binary systems provides a source of 'free–floating planets', which have been discovered recently. The formation of a large, tidally truncated cavity may provide an observational signature of circumbinary planets during formation. The existence of protoplanets orbiting stably just outside a mean motion resonance (4:1) in the simulations indicate that such sites may harbour planets in binary star systems, and these could potentially be observed. Finally, the formation of stable circumbinary planets in eccentric binary systems indicates that circumbinary planets may not be uncommon.

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Star forming cores in L 1251: maps and molecular abundances

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We have mapped the dense parts of the cometary–shaped, star–forming dark cloud L 1251 in the rotational lines of HCN, HNC, HCO^+ and CS at 3 mm, and observed selected positions in SO, CH_3CCH and rare isotopomers of the mapped molecules. Using the CS line we detected 15 cores with sizes of $\sim 0.1 - 0.3$ pc. New estimates of the fraction of dense gas in the cores yield a revised average SFE of ~ 10 %. Although 3 times lower than the previous estimate, this high SFE still points to externally triggered star formation in the cloud. Around IRAS 22343+7501, the source proposed to drive a previously detected extended CO outflow, our data suggest the existence of either a rotating HCO^+ disk or a dense outflow with a dynamical age of $\sim 2 \times 10^4$ years. A stability check seems to rule out the disk interpretation. We suggest that both continuum sources of Beltrán et al. are protostars each driving its own outflow. Using methyl acetylene as thermometer we find indications that at lower temperatures the A and E species are defined by different partition functions. A 'temperature gradient' was found in the cloud, with the highest temperature detected in the head region. The column density ratios derived from these observations and the previously published NH_3 data show in general little variations, but for two exceptional locations. One of these is in the tip of the 'head' with high relative SO and NH_3 abundances, and the other is in the 'tail' with low CO and HCO^+ column densities with respect to HNC, HCN and NH_3. In the first case the abundance ratios can probably be explained by an advanced stage of chemical evolution assisted by an elevated temperature. The second location is likely to be an example of CO and HCO^+ depletion, and the implication is that also HNC and HCN belong to the molecules which are more resistant against freezing–out than CO and HCO^+.

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Search for solid HDO in low-mass protostars

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We present ground-based 2.1 to 4.2 μm observations of four low-mass protostars. We searched for the 4.1 μm OD stretch band, characteristic of solid HDO in grain mantles. We did not detect solid HDO in any of the four sources, but we derive 3σ upper limits from 0.5% to 2% for the HDO/H_2O ratio depending on the source. These ratios provide strong constraints to solid-state deuteration models when compared to deuterium fractionation values observed in the gas phase. We discuss various scenarios that could lead to such a low water deuteration compared to the high formaldehyde and methanol deuteration observed in the gas-phase.

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Non-Gaussian velocity shears in the environment of low mass dense cores

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We report on a novel kind of small scale structure in molecular clouds found in IRAM-30m and CSO maps of ^{12}CO and ^{13}CO lines around low mass starless dense cores. These structures come to light as the locus of the extrema of velocity shears in the maps, computed as the increments at small scale (~ 0.02 pc) of the line velocity centroids. These extrema populate the non-Gaussian wings of the shear probability distribution function (shear-PDF) built for each map. They form elongated structures of variable thickness, ranging from less than 0.02 pc for those unresolved, up to 0.08 pc. They are essentially pure velocity structures. We propose that these small scale structures of velocity shear extrema trace the locations of enhanced dissipation in interstellar turbulence. In this picture, we find that a significant fraction of the turbulent energy present in the field would be dissipating in structures filling less than a few % of the cloud volume.

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Herbig-Haro Objects in Ophiuchus

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We report the results of a new [SII] and nearby off-line, narrowband continuum imaging survey of an approximately 0.5 sq. degree area of the ρ Ophiuchi cloud core. Higher sensitivity and an improved pixel scale ($0.37''$) over previous surveys has increased the inventory of Herbig-Haro flows in the cloud core. We report 11 independently discovered HH objects, or newly discovered components of known HH objects. Three previous candidate HH objects have been confirmed, and 7 new highly probable, and an additional 5 possible HH object candidates have been identified. The approximate number of independently driven outflows in the ρ Ophiuchi cloud core approaches 50 when the number of Herbig-Haro flows detected in the present study is combined with the number of known CO outflows. The number of outflows exceeds the number of known Class I/Class 0 objects in the same area by *at least* a factor of 2, leading to the conclusion that Class II and Class III objects must also be outflow drivers. There is direct evidence in these data for Class II and Class III Herbig-Haro flow drivers, although the lack of detected emission down to the sources themselves precludes definitive identification of the great majority of the driving sources.

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Bispectrum speckle interferometry of the massive protostellar outflow source AFGL 2591

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We present bispectrum speckle interferometry of the massive protostellar object AFGL 2591 in the near-infrared K band. Our reconstructed image of the outflow cavity of AFGL 2591 has a resolution of 170 mas, corresponding to physical scales of ~ 170 AU at the distance of the object, and shows the loops which extend from the bright, compact source in unprecedented detail. The central source is clearly resolved and has an uniform-disk diameter of ~ 40 mas (40 AU). We use 2D radiation transfer simulations to show that the resolved structure probably corresponds to the inner rim of a geometrically thick circumstellar disk or envelope at the dust sublimation radius. Our image also

reveals a structure that might represent an edge-on circumstellar disk around one of the other young stellar objects near AFGL 2591.

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On the formation time scale and core masses of gas giant planets

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Numerical simulations show that the migration of growing planetary cores may be dominated by turbulent fluctuations in the protoplanetary disk, rather than by any mean property of the flow. We quantify the impact of this stochastic core migration on the formation time scale and core mass of giant planets at the onset of runaway gas accretion. For standard Solar Nebula conditions, the formation of Jupiter can be accelerated by almost an order of magnitude if the growing core executes a random walk with an amplitude of a few tenths of an au. A modestly reduced surface density of planetesimals allows Jupiter to form within 10 Myr, with an initial core mass below 10 $M_{\oplus}$, in better agreement with observational constraints. For extrasolar planetary systems, the results suggest that core accretion could form massive planets in disks with lower metallicities, and shorter lifetimes, than the Solar Nebula.

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Detection of reactive ions in the ultracompact HII regions Mon R2 and G29.96-0.02

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We report the first detection of the reactive ions CO+ and HOC+ towards ultracompact (UC) HII regions, particularly in Mon R2 and G29.96-0.02. We have observed two positions in Mon R2, namely the peak of the UC HII region and a position in the high density molecular cloud which bounds it. CO+ and HOC+ were detected at the UC HII region but not at the molecular cloud, as expected if the CO^+ and HOC^+ emissions arise in the PDR surrounding the ultracompact HII region. The measured CO^+ and HOC^+ column densities are of the order of 10^{11} cm^{-2} in both sources, which yields a strikingly low [HCO^+]/[HOC^+] abundance ratio of 460 in Mon R2. These values are similar to those found in some other well-known PDRs, like NGC 7023 and the Orion Bar. We briefly discuss the chemical implications of these results.

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Numerical simulations of highly collimated protostellar outflows. The effects of relative density

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We present three-dimensional hydrodynamic simulations of jets as a model for protostellar outflows. We investigate molecular jets which are initially heavier, equal or lighter than a uniform ambient molecular medium, as well as a

ballistic atomic jet, with the aim of distinguishing the resulting structures and relating them to various proposed protostellar evolutionary stages. We modify the ZEUS numerical code, to include time-dependent molecular hydrogen chemistry, a limited equilibrium C and O chemistry, and a detailed cooling function. We find highly focussed and accelerated flow patterns for outflows driven by molecular jets, caused by the combined strong cooling, small imposed jet shear and precession. We also find shoulders in the interface with associated shocks visible in our simulated near-infrared H_2 images. The shoulder location relative to the front of the bow shock distinguishes the relative density. Apart from this, the outflow structures are quite similar provided the jet is molecular. The ratio of jet power to H_2 1–0 S(1) line luminosity (increasingly required to interpret observations), is generally in the range 80–600. Sub-millimetre CO properties, including a velocity-position and velocity-channel diagram; are presented. We compare mass-velocity relationships derived directly and via the simulated CO data: significant systematic differences are uncovered. For the future, we identify fine-scale structure in the rotational CO 2–1 and CO 14–13 rotational lines which can be resolved with the millimetre array ALMA and the Herschel (FIRST) Observatory. We identify highly collimated outflows in the near-infrared that can be interpreted by this model.

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Giant Molecular Clouds in M33 II – High Resolution Observations

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We present $^{12}CO(1 \rightarrow 0)$ observations of 45 giant molecular clouds in M33 made with the BIMA array. The observations have a linear resolution of 20 pc, sufficient to measure the sizes of most GMCs in the sample. We place upper limits on the specific angular momentum of the GMCs and find the observed values to be nearly an order of magnitude below the values predicted from simple formation mechanisms. The velocity gradients across neighboring, high-mass GMCs appear preferentially aligned on scales less than 500 pc. If the clouds are rotating, 40% are counter-rotating with respect to the galaxy. GMCs require a braking mechanism if they form from the large scale radial accumulation of gas. These observations suggest that molecular clouds form locally out of atomic gas with significant braking by magnetic fields to dissipate the angular momentum imparted by galactic shear. The observed GMCs share basic properties with those found in the Galaxy such as similar masses, sizes, and linewidths as well as a constant surface density of 120 $M_\odot$ pc^{-2}. The size–linewidth relationship follows $\Delta V \propto r^{0.45\pm0.02}$, consistent with that found in the Galaxy. The cloud virial masses imply that the CO-to-H_2 conversion factor has a value of 2×10^{20} H_2 cm^{-2}/(K km s^{-1}) and does not change significantly over the disk of M33 despite a change of 0.8 dex in the metallicity.

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Magnetorotational instability in stratified, weakly ionised accretion discs

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We present a linear analysis of the vertical structure and growth of the magnetorotational instability in stratified, weakly ionised accretion discs, such as protostellar and quiescent dwarf novae systems. The method includes the effects of the magnetic coupling, the conductivity regime of the fluid and the strength of the magnetic field, which is initially vertical. The conductivity is treated as a tensor and assumed constant with height.

We obtained solutions for the structure and growth rate of global unstable modes for different conductivity regimes, strengths of the initial magnetic field and coupling between ionised and neutral components of the fluid. The envelopes of short-wavelength perturbations are determined by the action of competing local growth rates at different heights, driven by the vertical stratification of the disc. Ambipolar diffusion perturbations peak consistently higher above the midplane than modes including Hall conductivity. For weak coupling, perturbations including the Hall effect grow faster and act over a more extended cross-section of the disc than those obtained using the ambipolar diffusion

approximation.

Finally, we derived an approximate criterion for when Hall diffusion determines the growth of the magnetorotational instability. This is satisfied over a wide range of radii in protostellar discs, reducing the extent of the magnetic 'dead zone'. Even if the magnetic coupling is weak, significant accretion may occur close to the midplane, rather than in the surface regions of weakly-ionised discs.

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The Nature of the Massive Young Stars in W75 N

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We have observed the W75 N massive star forming region in SiO(J=2–1 & J=1–0) at $3'' - 5''$ resolution and in 6 cm, 2 cm, and 7 mm continuum emission at $1.4'' - 0.2''$ resolution. The abundance ratio of $[SiO]/[H_2] \sim 5 - 7 \times 10^{-11}$ which is typical for what is expected in the ambient component of molecular clouds with active star formation. The SiO morphology is diffuse and centered on the positions of the ultracompact HII regions – no collimated, neutral jet was discovered. The ionized gas surrounding the protostars have emission measures ranging from $1 - 15 \times 10^6$ pc cm^{-6}, densities from $0.4 - 5 \times 10^4$ cm^{-3}, and derived spectral types of the central ionizing stars ranging from B0.5 to B2. Most of the detected sources have spectral indicies which suggest optically thick to moderately optically thick HII regions produced by a central ionizing star. The spread in ages between the oldest and youngest early-B protostars in the W75 N cluster is $0.1 - 5 \times 10^6$ years. This evolutionary timescale for W75 N is consistent with that found for early-B stars born in clusters forming more massive stars ($M_\star > 25 M_\odot$).

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Physical Properties and Kinetic Structure of a Starless Core in Taurus Molecular Cloud

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We have made synthesis imaging of a starless core in the Taurus Molecular Cloud, L1521F, with two key chemical evolutionary tracers, CCS ($J_N = 3_2 - 2_1$), which traces young evolutionary phase of cores, and N_2H^+ ($J = 1 - 0$), which traces until the late evolutionary phase, as well as mapping observations of submillimeter dust continuum. The peak positions as well as radial distributions of N_2H^+ and dust continuum coincide with each other. Unlike the other tracers, CCS shows a dip at the dust continuum center, suggesting that the abundance of the molecule decreases at the core center due to depletion and chemical reactions.

The channel maps of both molecular lines clearly revealed clumpy substructures inside the core. Using an automatic and objective routine, 8 and 4 clumps have been identified in the CCS and N_2H^+ channel maps, respectively. The abundances of the molecules are estimated towards the dust continuum center. Using our derived abundances, the LTE masses for each clump are estimated. The CCS components, which appear to trace the envelope, show an overall velocity gradient from east to west, whereas a N_2H^+ clump located at the core center shows a gradient from west to east. Assuming the velocity gradients are due to rotation, the observational results indicate that the rotation of the outer envelope (size $\lesssim 0.08$ pc ~ 16000 AU) and that of the central compact region (size $\lesssim 0.03$ pc ~ 6000

AU) have different axes with almost opposite sense of rotation. The velocity gradients of the southern and northern CCS components are estimated to be 7.2 km s^{-1} pc^{-1} and 9.2 km s^{-1} pc^{-1} at size scales of 0.05 pc and 0.04 pc, respectively. The velocity gradient of the N_2H^+ components at the core center is estimated to be 15 km s^{-1} pc^{-1} at a size scale of 0.01 pc ($\sim$ 2000 AU). Examining the line width - size correlation of these clumps and of other cold (kinetic temperature $T_K \lesssim 10$ K) starless cores, the slope index is found to be slightly shallower than those values for cores containing stars. Assuming a spherical, homogeneous sphere, the ratio of rotational to gravitational energy, β, of these cores are calculated to be $\sim$ 0.3 for the CCS and $\sim$ 1.0 for the N_2H^+ components, respectively. The specific angular momentum (J/M) - size relation seen at scales larger than $\sim$ 0.03 pc ($\sim$ 6000 AU) appears to flatten out at sizes smaller than $\sim$ 6000 AU, for which the specific angular momentum is relatively constant at $\sim$ 0.002. This is consistent with results reported by Ohashi et al. 1997. Based on a chemical evolutionary model, the core may be in a young starless cores phase, assuming the dip of CCS at the core center is caused by depletion and chemical reaction. L1521F may be in a younger starless core phase compared to L1544.

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http://cfa-www.harvard.edu/~hshinnaga/pub.html
ftp://ftp.nro.nao.ac.jp/nroreport/no595.pdf

The weak-line T Tauri star V410 Tau
I. A multi-wavelength study of variability

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We present the results of an intensive coordinated monitoring campaign in the optical and X-ray wavelength ranges of the low-mass, pre-main sequence star V410Tau carried out with the aim to study the relation between various indicators for magnetic activity that probe emission from different atmospheric layers: optical photometric star spot (rotation) cycle, chromospheric Hα emission, and coronal X-rays.

Two X-ray pointings were carried out with the Chandra satellite simultaneously with the optical observations, and centered near the maximum and minimum levels of the optical lightcurve. A relation of their different count levels to the rotation period of the dominating spot is not confirmed by a third Chandra observation carried out some months later, during another minimum of the 1.87 d cycle. Similarly we find no indications for a correlation of the Hα emission with the spots' rotational phase.

The extraordinary stability of the largest spot is confirmed by long-term photometric and radial velocity measurements. Joining our optical photometry with previous data we provide a new estimate for the dominant periodicity of V410Tau. This updated value removes systematic offsets of the time of minimum observed in data taken over the last decade. Furthermore, the combination of the new data with published measurements taken during the last decade allows us to examine long-term changes in the mean light level of the photometry of V410Tau. A variation on the timescale of 5.4 yr is suggested. Assuming that this behavior is truely cyclic V410Tau is the first pre-main sequence star on which an activity cycle is detected.

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http://www.astropa.unipa.it/~stelzer/publications.html

A Subarcsecond Companion to the T Tauri Star AS 353B

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Adaptive optics imaging of the bright visual T Tauri binary AS 353 with the Subaru Telescope shows that it is a hierarchical triple system. The secondary component, located 5.″6 south of AS 353A, is resolved into a subarcsecond binary, AS 353Ba and Bb, separated by 0.″24. Resolved spectroscopy of the two close components shows that both have nearly identical spectral types of about M1.5. Whereas AS 353A and Ba show clear evidence for an infrared excess, AS 353Bb does not. We discuss the possible role of multiplicity in launching the large Herbig-Haro flow associated with AS 353A.

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The Angular Momentum Evolution of 0.1-10 $M_\odot$ stars from the Birthline to the Main Sequence

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Projected rotational velocities (*vsini*) have been measured for a sample of 145 stars with masses between 0.4 and >10 $M_\odot$ (median mass 2.1 $M_\odot$) located in the Orion star-forming complex. These measurements have been supplemented with data from the literature for Orion stars with masses as low as 0.1 $M_\odot$. The primary finding from analysis of these data is that the upper envelope of the observed values of angular momentum per unit mass (J/M) varies as $M^{0.25}$ for stars on *convective* tracks having masses in the range ∼0.1 to ∼3 $M_\odot$. This power law extends smoothly into the domain of more massive stars (3 to 10 $M_\odot$), which in Orion are already on the ZAMS. This result stands in sharp contrast to the properties of main sequence stars, which show a break in the power law and a sharp decline in J/M with decreasing mass for stars with $M < 2\ M_\odot$. A second result of our study is that this break is seen already among the PMS stars in our Orion sample that are on *radiative* tracks, even though these stars are only a few million years old. A comparison of rotation rates seen for stars on either side of the convective-radiative boundary shows that stars do not rotate as solid bodies during the transition from convective to radiative tracks.

As a preliminary demonstration of how observations can be used to constrain the processes that control early stellar angular momentum, we show that the broad trends in the data can be accounted for by simple models that posit that stars: 1) lose angular momentum before they are deposited on the birthline, plausibly through star-disk interactions; 2) undergo additional braking as they evolve down their convective tracks; and 3) are subject to core-envelope decoupling during the convective-radiative transition.

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http://www.astro.caltech.edu/∼lah/papers.html

Abstracts of recently accepted major reviews

Massive Stars: Their Birth Sites and Distribution

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The stellar IMF has been found to be an invariant Salpeter power-law ($\alpha = 2.35$) above about $1\,M_\odot$, but at the same time a massive star typically has more than one low-mass companion. This constrains the possible formation scenarios of massive stars, but also implies that the true, binary-star corrected stellar IMF should be significantly steeper than Salpeter, $\alpha > 2.7$. A significant fraction of all OB stars are found relatively far from potential birth sites which is most probably a result of dynamical ejections from cores of binary-rich star clusters. Such cores form rapidly due to dynamical mass segregation, or they are primordial. Probably all OB stars thus form in stellar clusters together with low-mass stars, and they have a rather devastating effect on the embedded cluster by rapidly driving out the remaining gas leaving expanding OB associations and bound star clusters. The distributed population of OB stars has a measured IMF with $\alpha \approx 4$, which however, does not necessarily constitute a different physical mode for isolated star formation. A steep field-star IMF is obtained naturally because stars form in clusters which are distributed according to a power-law cluster mass function.

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Control of Star Formation by Supersonic Turbulence

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Understanding the formation of stars in galaxies is central to much of modern astrophysics. However, a quantitative prediction of the star formation rate and the initial distribution of stellar masses remains elusive. For several decades it has been thought that the star formation process is primarily controlled by the interplay between gravity and magnetostatic support, modulated by neutral-ion drift (known as ambipolar diffusion in astrophysics). Recently, however, both observational and numerical work has begun to suggest that supersonic turbulent flows rather than static magnetic fields control star formation. To some extent, this represents a return to ideas popular before the importance of magnetic fields to the interstellar gas was fully appreciated. This review gives a historical overview of the successes and problems of both the classical dynamical theory, and the standard theory of magnetostatic support from both observational and theoretical perspectives. The outline of a new theory relying on control by driven supersonic turbulence is then presented. Numerical models demonstrate that although supersonic turbulence can provide global support, it nevertheless produces density enhancements that allow local collapse. Inefficient, isolated star formation is a hallmark of turbulent support, while efficient, clustered star formation occurs in its absence. The consequences of this theory are then explored for both local star formation and galactic scale star formation. It suggests that individual star-forming cores are likely not quasi-static objects, but dynamically collapsing. Accretion onto these objects varies depending on the properties of the surrounding turbulent flow; numerical models agree with observations showing decreasing rates. The initial mass distribution of stars may also be determined by the turbulent flow. Molecular clouds appear to be transient objects forming and dissolving in the larger-scale turbulent flow, or else quickly collapsing into regions of violent star formation. We suggest that global star formation in galaxies is controlled by the same balance between gravity and turbulence as small-scale star formation, although modulated by cooling and differential rotation. The dominant driving mechanism in star-forming regions of galaxies appears to be supernovae, while elsewhere coupling of rotation to the gas through magnetic fields or gravity may be important.

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A reprint is available at http://www.arxiv.org/abs/astro-ph/0301093

Single and Multiple Star Formation in Turbulent Molecular Cloud Cores

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Ph.D degree awarded: Dec 2002

We begin in part 1 with a brief review of observational evidence of star formation, along with theoretical mechanisms for multiple star formation. We review observations of velocity and density structure within molecular clouds, focusing on molecular cloud cores, within which which star formation occurs. Next, we briefly discuss statistics of multiple star formation, including stellar multiplicity fractions, and orbital elements. We extensively review proposed mechanisms for multiple star formation, emphasizing the essential concepts underlying each. We critically discuss the advantages and limitations of each of mechanism, and conclude that no existing mechanism has been demonstrated to produce binary and multiple star formation under conditions representative of actual molecular cloud cores.

In part 2, we detail our numerical methodology. We solve the equations of coupled radiative, self-gravitating hydrodynamics in the grey approximation, in three dimensions. Since dust provides the opacity under typical conditions in molecular clouds, it plays a crucial role in the energy budget within the cloud, and determines which regions become optically thick, heat up, and thereby arrest collapse. We discuss our dust model in some detail, along with its implicit assumptions and inherent limitations. Next, we detail a new methodology used to solve Poisson's equation in parallel on an adaptive mesh. We couple gravity to hydrodynamics on an adaptive mesh in a self-consistent, fully asynchronous fashion: finer grid levels with smaller grid spacing are advanced with a smaller timestep than coarser overlying grids with larger grid spacing, while taking into account possible mismatches occurring on different grid levels. This methodology represents a significant advance over previous adaptive mesh self-gravitating hydrodynamic numerical methods, which either used synchronous timestepping on all grid levels (at a large performance cost), or otherwise treated grid mismatches inconsistently. To test our methodology, we have examined two standard test cases: the gravitational collapse of an unperturbed, non-rotating, uniform sphere, and the gravitational collapse of a rigidly rotating, self-gravitating uniform sphere perturbed with a 10% $m = 2$ density perturbation. We compare these test results against analytic and previous numerical solutions, respectively, and find excellent agreement in both instances. We provide performance and parallelization benchmarks for our code on the IBM SP-2 Blue Horizon, at the National Partnership for Advanced Computing Infrastructure (NPACI).

In part three, we present the initial conditions for our models of turbulent molecular cloud cores for isolated star formation. Our models consist of centrally condensed Bonnor-Ebert spheres perturbed with a turbulent velocity field. Unlike the bulk of models of molecular cloud cores studied to date, in the absence of an applied perturbation, our cores are in exact mechanical equilibrium. The turbulent velocity field is generated as a realization of an $n = -4$ Gaussian field, which is consistent with observed linewidth-size relations. We discuss the similarities and differences between our turbulent velocity perturbations and Gaussian density perturbations used in studies of large scale cosmological structure.

Lastly, in part four, we present the results of the time evolution of the turbulent molecular cloud core models described in part three for several cores with varying degrees of turbulence. In order to assess the effect of radiative transfer, we also examine one model both with radiative transfer and with the barotropic approximation. We discuss a novel method of translating an adaptive mesh dataset to an irregularly gridded dataset, which allows us to analyze our data using a wide variety of existing numerical methods. We present an algorithm for finding gravitationally bound structures within a dataset. We discuss the transition from single to multiple star formation in our models, and its relation to observations of molecular cloud core linewidths. We conclude with a discussion of possible directions for future research.

Measuring the Density Structure of Star-Forming Dense Cores

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I have used two newly feasible observational techniques — dust extinction, and dust emission — and intensive computer modeling to measure the density structure of selected dense molecular cloud cores that are evolving to form stars: protostar Barnard 335, and contracting starless core Lynds 694–2. These measurements test competing theories of isolated star formation, the process by which stars like the Sun are formed. In particular, the studies of B335 provide insight into the dynamics of protostellar collapse, while the studies of L694–2 provide insight into the initial conditions.

The extinction study of B335 is the only extinction work that has been done with the Hubble Space Telescope. The data provide a quantitative test of the "inside-out" collapse model: the *shape* of the density profile is well matched by the model, but the *amount* of extinction corresponds to larger column densities than predicted. The emission observations constrain the flux from the circumstellar disk, and demonstrate an inner density structure consistent with the profile of gravitational free-fall, as predicted for the formation of a star. Combined, these studies constrain the density profile with a precision that is unique amongst protostellar cores.

The extinction study of L694–2 shows an outer density profile that is significantly steeper than the initial condition of the inside-out collapse model. The emission observations measure the inner density structure not probed with extinction, demonstrating a turn-over in the density profile to substantially more shallow behavior in the inner regions. The turn-over suggests that pressure forces still support the core, and that it has not relaxed to the singular initial condition of the inside-out collapse model, despite purported inward motions. A cylindrical model viewed nearly end-on reproduces all the observations remarkably well, including the apparent asymmetry of the core. In this context the inward motions may represent the contraction of a prolate core along its major axis. If the core is sufficiently magnetized then fragmentation may be avoided, and later evolution might produce a protostar similar to B335, with mass larger than expected for a spherically symmetric core.

Electronic version is available at: http://cfa-www.harvard.edu/ dwilner/dwah_thesis.pdf

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Brown Dwarfs in Star Forming Regions

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Ph.D degree awarded: June 2003

This thesis presents the results of a multiband survey for brown dwarfs in four southern star forming regions with the Wide Field Imager (WFI) camera at the ESO/MPG 2.2-m telescope of La Silla Observatory. Candidates were selected from RI and Hα imaging observations. We also observed in two medium-band filters, M855 and M915 (centered on 855 nm and 915 nm, respectively), for the purpose of spectral type determination. The former filter covers a wavelength range containining spectral features characteristic of M-dwarfs, while the latter lies on a relatively featureless region in these late-type objects. A correlation is found between spectral type and (M855–M915) colour index for mid- to late-type objects and early L-type dwarfs. With this method, we identify most of our object candidates as being of spectral type M5 or later.

The survey has revealed a substancial population of brown dwarfs in the Chamaeleon I and Lupus dark clouds. Our results show that there is no strong drop in the number of objects for the latest spectral types, hence brown dwarfs may be as abundant as low-mass stars in both regions. For the mass function $dN/dM \sim M^{-\alpha}$, we derive an exponent $\alpha = 0.9 \pm 0.1$ in Chamaeleon I and $\alpha = 1.1 \pm 0.2$ in Lupus, both very close to the value 0.8 ± 0.4 estimated by Béjar et al. (2001) for the similarly old σ Orionis cluster.

Stars and brown dwarfs are found to have similar spatial distributions, and they tend to be placed near the cloud cores. This is interpreted as a hint of their common origin. There are no indications that the less massive objects have been ejected from their birth sites. The scarse number of visual binaries, and especially of star-brown dwarf pairs, contradicts the picture of a planet-like formation, in disks around stars. Moreover, some of the brown dwarfs in both regions have strong Hα emission, evidence of accretion. For objects with published ISOCAM photometry in Chamaeleon I, we find that this strong Hα emission is related to a mid-infrared excess, indicative of the presence of a circumstellar disk.

We also investigated the magnetic activity of our candidates in Chamaeleon I using available ROSAT observations. Our results show no decrease of the X-ray emission with the spectral type down to M7.5, well below the substellar boundary. Thus, young brown dwarfs seem to be as active as very low-mass stars of similar age. No significant correlation is found between X-ray emission and Hα emission, a further indication that the latter is produced by accretion rather than by chromospheric activity.

In Chamaeleon II and Corona Australis, we find a number of faint objects that need spectroscopic confirmation of their status. Few or no objects with spectral type between M7 and M9 are identified in these regions, which may be a hint of a true deficit of brown dwarfs in both clouds. Contrary to Chamaeleon I and Lupus, strong Hα emitters are rare in these regions, and no relation between this emission and infrared excess could be established.

New Jobs

Post-doctoral Research Opportunities in Star and Planet Formation

The University of Arizona and the National Optical Astronomy Observatory

The Star and Planet Formation Research Group in Tucson anticipates having several post-doctoral research positions in the coming year.

Special projects/groups of interest include:

Formation and Evolution of Planetary Systems (SIRTF Legacy Science Program) http://feps.as.arizona.edu
Laplace Center (NASA Astrobiology Institute member node) http://caao.as.arizona.edu/laplace
The James Webb Space Telescope NIRCam Project: http://ircamera.as.arizona.edu/nircam
Star and Planet Formation Resarch Group: http://gould.as.arizona.edu/ mmeyer/origins
The Theoretical Astrophysics Program: http://www.astrophysics.arizona.edu/

For more general information please see:

Steward Observatory WWW Page: http://www.as.arizona.edu
The Lunar and Planetary Laboratory WWW Page: http://www.lpl.arizona.edu
The National Optical Astronomy Observatories: http://www.noao.edu

For further information, please contact:

Michael Meyer
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The University of Arizona
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Email: mmeyer@as.arizona.edu
URL: http://gould.as.arizona.edu/ mmeyer/mmeyer

STELLAR INITIAL MASS FUNCTION IN REGIONS OF EXTREME STAR FORMATION

The Star and Planet Formation Research Group/NIRCam project at Steward Observatory, the University of Arizona seeks applicants for a post-doctoral fellow interested in the origin of the stellar initial mass function. The successful candidate will collaborate with the PI (Michael Meyer) and co-Is Don McCarthy and Marcia Rieke in: 1) the conduct of ground– and space– based observations of the distribution of stellar (and sub-stellar) masses in extreme star-forming environments; and 2) the design, construction, and characterization of novel infrared instrumentation required to make these observations. A Ph.D. in astronomy, physics, or related field is required. Experience with adaptive optics, infrared instrumentation, near-IR spectroscopy, and/or statistical comparison of numerical models to observational data is highly desirable. Candidates with an interest in education and public outreach will receive special consideration. Successful candidates will have full access to the facilities of Steward Observatory including the 6.5m MMT and Magellan telescopes, the 2.3m Kitt Peak Bok telescope, the Heinrich-Hertz Sub-millimeter Telescope and starting in 2004 the Large Binocular Telescope on Mt. Graham. For more information, please visit the group WWW site at: http://gould.as.arizona.edu/ mmeyer/origins or http://ircamera.as.arizona.edu/nircam/

The position can be at the Research Associate or at the Assistant Astronomer level at Steward Observatory, at salaries from $ 38,000 to $ 47,000 depending on qualifications and experience. This position is initially for two years with the possibility for extension. The start date is expected to be September 1, 2004 although other start dates can be accommodated. Review of materials will begin December 1, 2003 and will continue until the position is filled. Please send a curriculum vitae, statement of experience and research interests, and the names of three references to Ms. Debra Wilson at the above address or apply via email to: dwilson@as.arizona.edu.

For more information please visit http://gould.as.arizona.edu/ mmeyer/mmeyer or email mmeyer@as.arizona.edu.

INFRARED SPECTROSCOPY OF CIRCUMSTELLAR GAS AND DUST AROUND SUN-LIKE STARS

The SIRTF Legacy Science Program "Formation and Evolution of Planetary Systems" seeks applicants for a postdoctoral fellow interested in the evolution of of circumstellar gas and dust surrounding Sun-like stars. The successful candidate will collaborate with the PI (Michael Meyer) and co-Is Joan Najita (NOAO) and David Hollenbach (NASA-Ames) in: 1) the analysis of high resolution IRS spectra obtained with SIRTF of stars known to harbor circumstellar disks; and 2) comparison of these results to theoretical models of disk chemistry and ancillary ground-based submillimeter and infrared data. A Ph.D. in astronomy, physics, planetary science or related field is required. Experience in infrared space astronomy, molecular spectroscopy, data reduction/software development and/or comparison of detailed theoretical models to observational data is highly desirable. Successful candidates will have full access to the facilities of Steward Observatory including the 6.5m MMT and Magellan telescopes, the 2.3m Kitt Peak Bok telescope, the Heinrich-Hertz Sub-millimeter Telescope and starting in 2004 the Large Binocular Telescope on Mt. Graham (http://www.as.arizona.edu/telescopes/telescopes.html). For more information, please visit the group WWW site at: http://feps.as.arizona.edu.

The position can be at the Research Associate or at the Assistant Astronomer level at Steward Observatory, at salaries from $ 38,000 to $ 47,000 depending on qualifications and experience. This position is initially for two years with the possibility for extension. The start date is expected to be September 1, 2004 although other start dates can be accommodated. Review of materials will begin December 1, 2003 and will continue until the position is filled. Please send a curriculum vitae, statement of experience and research interests, and the names of three references to Ms. Debra Wilson at the above address or apply via email to: dwilson@as.arizona.edu.

For more information please visit http://gould.as.arizona.edu/ mmeyer/mmeyer or email mmeyer@as.arizona.edu.

OBSERVATION/MODELING OF PLANETS AND DEBRIS DISKS AROUND SUN-LIKE STARS

The Univesity of Arizona/NOAO Laplace Center node of NASA's Astrobiology Institute seeks applicants for a postdoctoral fellow interested in the comparison of planetary systems around Sun-like stars to our own solar system. The successful candidate will collaborate with co-Is Michael Meyer, Phil Hinz, and Renu Malhotra in: 1) AO/nulling and infrared spectroscopic observations of planets and debris disks surrounding Sun-like stars; 2) dynamical modeling of dust disks in the presence of planets; and 3) comparison of observational and theoretical evidence for planetary systems around other stars to scenarios for the evolution of our own solar system. A Ph.D. in astronomy, physics, planetary science, or related field is required. Experience in high resolution imaging, infrared spectroscopy, dynamical modeling, and/or studies of solar system evolution is highly desirable. Successful candidates will have full access to the facilities of Steward Observatory including the 6.5m MMT and Magellan telescopes, the 2.3m Kitt Peak Bok telescope, the Heinrich-Hertz Sub-millimeter Telescope and starting in 2004 the Large Binocular Telescope on Mt. Graham (http://www.as.arizona.edu/telescopes/telescopes.html), well as affiliation with the Theoretical Astrophysics Program at the University of Arizona (http://www.astrophysics.arizona.edu/). For more information, please visit the group WWW site at: http://caao.as.arizona.edu/laplace.

The position can be at the Research Associate or at the Assistant Astronomer level at Steward Observatory, at salaries from $ 38,000 to $ 47,000 depending on qualifications and experience. This position is initially for two years with the possibility for extension. The start date is expected to be September 1, 2004 although other start dates can be accommodated. Review of materials will begin December 1, 2003 and will continue until the position is filled. Please send a curriculum vitae, statement of experience and research interests, and the names of three references to Dr. Anna Spitz at the address below or apply via email to: aspitz@as.arizona.edu.

For more information please visit http://gould.as.arizona.edu/ mmeyer/mmeyer or email mmeyer@as.arizona.edu.

POSTDOCTORAL POSITION IN THE THEORY OF EXTRASOLAR PLANETS AND BROWN DWARFS

The University of Arizona Department of Astronomy invites applications for a postdoctoral research associate position to work on the theory of extrasolar planet and brown dwarf evolution, spectra, and interiors. Expertise in atmospheric physics, radiative transfer, molecular opacities, or chemical equilibria is highly desired, but not required, and strong candidates from any subfield of astrophysics or planetary science will be considered seriously. By the start date, the successful candidate must have a Ph.D. in Astronomy, Planetary Sciences, Physics, or a related field.

He/she will work with Adam Burrows and Jonathan Lunine to provide theoretical support for the planet and brown dwarf search component of the University of Arizona's LAPLACE astrobiology center, a node of the NASA Astrobiology Institute. In addition, he/she will be a member of the Arizona Theoretical Astrophysics Program and will have access to both advanced workstations and the facilities of Steward Observatory.

The appointment could be for as many as three years, subject to availability of funding and suitable performance on the part of the appointee. To apply, please submit a CV, a list of publications, and a statement of research interests and accomplishments and have three letters of reference in support of the candidate sent directly to Professor Adam Burrows at the above address. The application review process will begin December 1, 2003 (though applications after this time will certainly be entertained) and will continue until the position is filled. For further information , contact Adam Burrows.

POSTDOCTORAL RESEARCH ASSOCIATE IN STAR AND PLANET FORMATION

The National Optical Astronomy Observatory (NOAO) invites applications for a postdoctoral research associate to work with Joan Najita on the study of planet formation environments. Applicants with theoretical experience in astrochemistry and/or an observational background in infrared spectroscopy are particularly encouraged to apply. The specific responsibilities of the position are flexible depending on the interests and background of the postdoc. Possible responsibilities include the development of thermal-chemical models for gaseous disk atmospheres, and the reduction and analysis of ground-based (Keck, Gemini) and space-based (SIRTF/IRS) spectroscopy of young planet-forming disks.

The postdoc, while holding an appointment at NOAO, will also be a member of LAPLACE (Life And PLanets Astrobiology CEnter), a partnership between the University of Arizona and NOAO, and a newly-created node of NASA's Astrobiology Institute. The research interests of current LAPLACE members include solar-stellar astrophysics, star and planet formation, the detection and characterization of extra-solar planetary systems, and the emergence and evolution of life in the Universe. LAPLACE is expected to create an exciting interdisciplinary atmosphere with many opportunties for interaction among Center members (see http://caao.as.arizona.edu/laplace).

Applicants should have obtained by the starting date a Ph.D. in astronomy or a related field. The appointment is for 3 years with a possible extension. Interested applicants are asked to submit by January 15, 2004 a CV, list of publications, and a statement of current and future research interests to the above address. Please also arrange to have three letters of reference sent to the same address. Questions regarding this position are welcome and may be directed to Joan Najita at 520-318-8416 or najita@noao.edu.

NOAO is an equal opportunity and affirmative action employer. We value and foster a diverse research environment. Women and underrepresented minorities are particularly encouraged to apply.

The Star Formation Newsletter is a vehicle for fast distribution of information of interest for astronomers working on star formation and molecular clouds. You can submit material for the following sections: *Abstracts of recently accepted papers* (only for papers sent to refereed journals, not reviews nor conference notes), *Dissertation Abstracts* (presenting abstracts of new Ph.D dissertations), *Meetings* (announcing meetings broadly of interest to the star formation and interstellar medium community), *New Books* (giving details of books relevant for the same community), *New Jobs* (advertising jobs specifically aimed towards persons within our specialty), and *Short Announcements* (where you can inform or request information from the community).

Latex macros for submitting abstracts and dissertation abstracts are appended to each issue of the newsletter.

The Star Formation Newsletter is available on the World Wide Web at http://www.ifa.hawaii.edu/~reipurth or at http://www.eso.org/gen-fac/pubs/starform/ .

New Books

Extragalactic Star Clusters

Edited by Doug Geisler, Eva Grebel, and Dante Minniti

These are the proceedings of IAU Symposium No. 207 held in Pucon, Chile on 12-16 March 2001. Star clusters are observed in a wide variety of environments and are present in all but the least massive galaxies, and their study can tell us much about both cluster and galaxy formation. Most stars are born in massive clusters, and this book is therefore of considerable relevance to the star formation community. The book is dividided into 5 parts:

1. **The Star Clusters of Local Group Galaxies**
2. **Globular Cluster Systems of Distant Galaxies**
3. **Super Star Clusters and Associations**
4. **Star Cluster Formation and Evolution: Theory and Observation**
5. **Future Prospects and Conference Summary**

The book contains 59 papers and a large number of poster papers, and includes the following 22 larger presentations and reviews:

Metal-Poor Globular Clusters of the Milky Way and Environs *J. Hesser & J. Fulbright*
Bulge Globular Clusters *B. Barbuy, S. Ortolani, & E. Bica*
The Galactic System of Open Clusters: A Personal Perspective *R. Phelps*
Metal-rich and Metal-poor Globular Clusters in Ellipticals *M. Kissler-Patig*
Globular Cluster Subpopulations in Early-Type Galaxies *J. Brodie*
New Insights from a Study of the Globular Cluster Systems of 60 early-type Galaxies *A. Kundu & B. Whitmore*
Super Stellar Clusters in HII Galaxies *E. Telles*
The Formation and Evolution of Young Star Clusters in the Antennae *B. Whitmore*
Triggering the Formation of Young Clusters *B. Elmegreen*
Systematic Properties of Young Clusters and AQssociations in Galaxies *R. Kennicutt, F. Bresolin, & A. Dolphin*
Clusters in Extragalactic HII Regions and their Modelling *R. González Delgado*
Star Formation in Large N Clusters *C. Clarke*
A Revised CO View of the Large Magellanic Cloud with NANTEN *Y. Fukui*
The Mass Function of Young Star Clusters in our Galaxy and Nearby Galaxies: Is it Universal? *R. Sagar*
Cluster Mass and Metallicity Distributions: Reconstructing the Events during Hala Formation *W. Harris*
Mass Determinations of Star Clusters *G. Meylan*
Formation and Disruption of Globular Star Clusters *S. Fall & Q. Zhang*
The Life and Death of Globular Clusters *H. Lee*
Old and New Tools for Understanding the Evolution of Stars in Clusters *F. D'Antona*
Evolution of Globular Clusters Formed in Mergers *F. Schweizer*
Formation Scenarios for Globular Clusters and their Host Galaxies *S. Zepf*
Extragalactic Star Clusters: Speculations on the Future *J. Gallagher & E. Grebel*

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Cores, Disks, Jets and Outflows in Low and High Mass Star Forming Environments: Observations, Theory and Simulations

12-16 July 2004

The Banff Centre, Banff, Alberta, Canada

The Physics and Astronomy department at the University of Calgary would like to welcome you to attend *Cores, Disks, Jets and Outflows in Low and High Mass Star Forming Environments: Observations, Theory and Simulations* in July, 2004.

Although much is known about the process of low-mass star formation, relatively little is known about the formation of high mass stars. Therefore, the main conference goal is to critically review the recent, major progress in high mass star formation and compare and contrast this to what is known about the formation of low mass stars. The conference will focus specifically on the relationships between high and low mass cores, disks, jets and outflows - how they form from, and interact with, the surrounding star forming environment. By confronting theory with observations, in both high and low mass star forming regions, we hope to bring together the various strands of research that comprise these fields, and examine whether a unified theory of star formation is possible.

Conference Location

The conference will be held at the Banff Centre in the beautiful town of Banff located in Banff National Park (A UNESCO World heritage site in the Canadian Rockies). The Banff Center is approximately a 15-20 minute uphill walk from downtown Banff. One interesting facet of the meeting is that it coincides with the start of the Banff Summer Arts Festival. The BSAF draws artists from around the world (dancers, actors, musicians, singers etc.) and they will be living, eating, performing and practicing at various locations on the Banff Center Campus.

Local Organisers (University of Calgary):
René Plume
Rachid Ouyed

Scientific Advisory Committee:

P. André (CEA, France)
A. Brandenburg (Nordita, Denmark)
E. Churchwell (U. of Wisconsin, USA)
L. Hartmann (CfA, USA)
R. Ouyed (University of Calgary, Canada)
R. Plume (University of Calgary, Canada)
R. Pudritz (McMaster University, Canada)
E. Zweibel (U. of Wisconsin, USA)

As further information becomes available, it will be posted at the conference web site:

http://www.ism.ucalgary.ca/meetings/banff

THE NATURE AND EVOLUTION OF DISKS AROUND HOT STARS

A workshop on disks around hot stars is being planned for 2004 July 7-9, to be hosted by East Tennessee State University in Johnson City, Tennessee (www.etsu.edu), with meetings to be held at the Carnegie Hotel (www.CarnegieHotel.com).

Disks are an important, sometimes even dominant, feature of many astrophysical sources, including massive hot stars. Studies of these disks are often constrained by narrow categories of objects, while the key physical principles for understanding the disks in different systems can be quite similar. This workshop is intended to focus discussion on the major outstanding questions surrounding the structure, formation, and evolution of disks around hot stars, and to foster communication between different areas of disk research. With a balanced menu of observational and theoretical presentations, review talks will highlight recent results and key physical principles relating to these topics. In keeping with the workshop theme, substantial time will be allocated for discussion, both in a moderated large group setting and in the casual formation of smaller circles of participants. The intended outcome of this event is the synthesis of the latest observational data and theoretical tools to stimulate fresh approaches for this interesting and growing topic of relevance for massive stars.

Jon Bjorkman *Modelling the Structure of Hot Star Disks* (confirmed)

Karen Bjorkman *The Observed Properties of Hot Star Disks* (confirmed)

Joseph Cassinelli *The Effects of Magnetic Fields in Winds and Disks* (confirmed)

Janet Drew *Winds from Hot Star Disks* (tbc)

Carol Grady *Evidence of Disks in Herbig Stars* (confirmed)

Lee Hartmann *The Physics of Circumstellar Disks* (tbc)

Huib Henrichs *Magnetism Observed in Massive Stars* (tbc)

Michael Jura *Dusty Disks Across the HR Diagram* (confirmed)

Keith MacGregor *Generating Magnetic Fields in Early-Type Stars* (confirmed)

Georges Meynet *The Influence of Rotation for Massive Star Evolution: Principles and Uncertainties* (confirmed)

Stan Owocki *Dynamical Processes that Drive the Evolution of Hot Star Disks* (tbc)

Thomas Rivinius *Links Between Hot Stars and Their Disks* (confirmed)

We have developed a novel format for the meeting. For each day there will be four invited talks in the morning, with a discussion session in the early afternoon. A "Focus" session will be held later in the afternoon, for which attendence will be optional.

Our goal is twofold: first, to provide review talks to summarize the current understanding of hot star disks and set the stage for discussion (the three sessions being "The Properties of Hot Star Disks", "The Star-Disk Connection", and "Magnetic Fields in Massive Stars"). A lunch break will provide a period of time for informal discussion, after which participants will gather for a moderated discussion led by a panel. The Focus sessions are more narrowly defined and are intended to be somewhat tutorial in nature, on the topics of Diagnostic Methods (headed by David Cohen and Margaret Hanson), Modelling Tools (headed by Ken Gayley and John Porter), and Optical/IR Interferometry (headed by Doug Gies and Philippe Stee).

The workshop format is thus built around a relatively small number of review talks, with plenty of time for interaction, in hopes of achieving a kind of "summer school" flavor. We would like participants to come away with a deeper understanding of the key issues and with new ideas for attacking the outstanding questions surrounding hot star disks. We hope to stimulate new collaborations and working partnerships for further progress in this area.

SOC: Richard Ignace, Karen S. Bjorkman, Joseph P. Cassinelli, and Kenneth G. Gayley.

For questions or more information, contact

hotstars@mail.etsu.edu